DOCUMENT RESUME

ED 121 351 IR 003 366

AUTHOR Brecke, Fritz H.; And Others
TITLE The Role of Verbal Prescriptive Rules in Cognitive Pretraining for a Flying Task.
INSTITUTION Arizona State Univ., Tempe. Coll. of Education.
SPONS AGENCY Air Force Office of Scientific Research, Arlington, Va.
REPORT NO AFOSR-75-2900; ASU-TR-60201
PUB DATE 76
NOTE 32p.; Studies in Systematic Instruction and Training

EDRS PRICE MF-$0.83 HC-$2.06 Plus Postage
DESCRIPTORS *Cues; Educational Research; *Flight Training; *Perceptual Motor Learning; Post Secondary Education; Recall (Psychological); Simulators; Teaching Methods; *Time Factors (Learning); Transfer of Training

ABSTRACT

Forty-five student pilots were the subjects of a study to identify variables which influence transfer from cognitive pretraining to perceptual-motor skill acquisition. The subjects were divided into four experimental groups. All groups used a linear self-instructional program designed to teach a specific flying maneuver. All programs had the same introductory section on the maneuver, the same division of maneuver segments, and identical mastery items requiring an overt written response. Feedback was provided after each response. The program versions differed from each other by type of instrucitonal cue and amount of practice. Two programs contained systematically developed cues, and two contained currently operational cues. Program versions with the same level of cues incorporated either a high or a low amount of practice. It was found that systematic instructional cues resulted in a superior posttest performance. The amount of cognitive practice with a given set of cues did not influence posttest scores, but it did lead to differences in posttest time. Subjects in the high practice group had significantly shorter posttest time, indicating they recalled cues more readily. (JY)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED121351

Rule Learning and Systematic Instruction in
Undergraduate Pilot Training

Vernon S. Gerlach, Principal Investigator

THE ROLE OF VERBAL PRESCRIPTIVE RULES IN COGNITIVE PRETRAINING FOR A FLYING TASK

Fritz H. Brecke
Vernon S. Gerlach
Richard F. Schmid

Technical Report #60201

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

Research sponsored by the Air Force Office of Scientific Research, Air Force Systems Command, USAF, under Grant No. AFOSR 75-2900. The United States Government is authorized to reproduce and distribute reprints for governmental purposes nothwithstanding any copyright notation hereon.

College of Education
Arizona State University
Tempe, Arizona

IR 003 366

PERMISSION TO REPRODUCE THIS COPYRIGHTED MATERIAL HAS BEEN GRANTED BY

[illegible]

TO ERIC AND ORGANIZATIONS OPERATING UNDER AGREEMENTS WITH THE NATIONAL INSTITUTE OF EDUCATION. FURTHER REPRODUCTION OUTSIDE THE ERIC SYSTEM REQUIRES PERMISSION OF THE COPYRIGHT OWNER.

Copyright 1976
Arizona State University
All rights reserved

Contents

		Page
I.	Verbal Rules in Skill Acquisition	1
II.	Method	7
	Subjects and Design	7
	Apparatus	7
	Treatment Materials	7
	Levels of Instructional Cue	8
	Systematically developed cues	8
	Currently operational cues	8
	Levels of Practice	9
	Program Development	9
	Procedure	9
	Data Collection and Analysis	10
	Last Data	11
	Performance Descriptors	11
III.	Results	13
	Cognitive Performance	14
	Perceptual-Motor Performance	14
	Straight and level warm-up	14
	Vertical 5 Trials	17
	Questionnaire	17
IV.	Discussion	23
	References	27
	Appendix	29

List of Tables

Table Page

1 [illegible] 10

2 [illegible] 10

Table of Figures

Figure Page

1 [illegible] 47

2 [illegible] 48

3 [illegible] 49

The acquisitions of semiconductor device companies by conglomerates have caused many interesting developments in antitrust jurisprudence. Cases, such as Procter & Gamble, Ford, Brown Shoe, and Philadelphia National Bank, have been instrumental in establishing broad antitrust principles governing the acquisitions of small companies by large companies. Many of these principles are applicable to semiconductor mergers and acquisitions. However, there are also important differences between the semiconductor industry and the industries involved in the cases mentioned above. These differences may affect the application of antitrust principles to semiconductor acquisitions. Some of the differences between the semiconductor industry and the industries involved in the cases mentioned above are discussed below.

Several recent semiconductor acquisitions have involved companies that are not in the traditional sense of the word semiconductor device companies. Rather, they are manufacturers of computers and communications equipment which have acquired semiconductor companies in order to secure a source of supply of semiconductor devices. Examples of such acquisitions are the acquisition of Fairchild Camera and Instrument Corporation by Schlumberger Limited, the acquisition of Signetics Corporation by Corning Glass Works, the acquisition of Monolithic Memories, Inc. by Data General Corporation, and the acquisition of Intersil, Inc. by Electronic Associates, Inc. Although these companies are not traditional semiconductor companies, they are nevertheless significant competitors in the semiconductor industry. Their acquisitions of semiconductor companies have had significant effects on the competitive structure of the semiconductor industry. Therefore, these companies should be considered in defining the relevant product market and in determining the competitive effects of their acquisitions of semiconductor companies.

Another aspect of the semiconductor industry which may be relevant in determining the competitive effects of semiconductor acquisitions is the existence of joint ventures between semiconductor companies and companies in other industries. For example, Texas Instruments Incorporated has entered into joint ventures with companies in the computer industry and the telephone industry. Such joint ventures may be relevant in determining the competitive effects of semiconductor acquisitions. For example, if a joint venture between a semiconductor company and a computer company is terminated by the acquisition of the semiconductor company by another computer company, the acquisition may have the effect of eliminating potential competition between the computer companies in the production and sale of semiconductor devices. Similarly, if a joint venture between a semiconductor company and a computer company is terminated by the acquisition of the semiconductor company by another semiconductor company, the acquisition may have the effect of eliminating potential competition between the computer company and the semiconductor company in the production and sale of semiconductor devices. Joint ventures between semiconductor companies and companies in other industries may also be relevant in determining the competitive effects of semiconductor acquisitions. For example, if a joint venture between a semiconductor company and a company in another industry is terminated by the acquisition of the semiconductor company by another semiconductor company, the acquisition may have the effect of eliminating potential competition between the company in the other industry and the semiconductor company in the production and sale of semiconductor devices.

Another issue which may be relevant in determining the competitive effects of semiconductor acquisitions is the existence of joint ventures between semiconductor companies and companies in other industries. For example, if a joint venture between a semiconductor company and a company in another industry is terminated by the acquisition of the semiconductor company by another semiconductor company, the acquisition may have the effect of eliminating potential competition between the company in the other industry and the semiconductor company in the production and sale of semiconductor devices. Similarly, if a joint venture between a semiconductor company and a company in another industry is terminated by the acquisition of the semiconductor company by another semiconductor company, the acquisition may have the effect of eliminating potential competition between the company in the other industry and the semiconductor company in the production and sale of semiconductor devices.

each response. The four program versions differed from each other by [illegible] versions contained systematically developed cues and two contained currently operational cues. Program versions with the same level of cues incorporated either a high or a low amount of practice. Each program included a posttest at the end. The posttest was identical for all four versions.

The program for the control group had the same introductory section as the four experimental programs. This section was followed by blank pages on which the students were to write in their own words the steps they would follow in executing the maneuver.

The development of the levels of the two independent variables, Instructional Cues and Practice, is described in the following paragraphs.

Levels of Instructional Cue

Systematically developed cues. This set of cues was developed with the aid of a maneuver analysis (Brecke et al., 1972; Gerlach et al., 1972). This analysis specifies three classes of information for every maneuver segment: Aircraft Parameters, Control Parameters and Information Sources. Instructional cues were generated by applying a quasi-algorithmic procedure to the comprehensive and precise information base generated by the analysis. A set of cues generated by one subject matter expert was highly consistent, in terms of cue content, with a set generated by three instructional design experts. However, the two sets were somewhat less consistent with one another in terms of syntax. The most concisely formulated cues from either set were combined into one list which was then subjected to four revision cycles, during which student as well as instructor pilot judgments generated during actual maneuver performance were analyzed and incorporated.

Currently operational cues. This set of cues was developed from current instructional materials. Briefings on the Vertical S-A maneuver given by eight different instructor pilots were covertly recorded in the normal instructional environment, i.e., on the flight line. Transcriptions of all eight briefings were then distributed to four judges who independently identified the instructional cues contained in the briefings. Even though the judges differed greatly in terms of subject-matter knowledge, interrater reliability was in excess of .80 (Brecke et al., 1974). Two judges, independently of each other, then classified the cues as either functional or nonfunctional. A stratified random sample drawn from the pool of cues thus subdivided constituted the set of current operational cues.

The sets of currently operational cues and systematically developed cues were equivalent with respect to number of cues. The two sets constituted the subject matter for the instructional program.

Levels of Practice

The variable "practice" was operationally defined in terms of two levels: the minimal and the maximal amount of practice which appear to be feasible with the type of instructional treatment (programmed instruction) selected. The minimal amount of practice for the complete set of cues for one maneuver segment was one mastery item, which required the learner to "name in correct order" the cues for the segment to which he had been introduced in the preceding frames. In the maximal or high level practice condition, the learner had to respond to the same first item as the low practice groups but then had to emit the same response two more times, once in conjunction with the cues for the preceding segment and once in conjunction with the cues for the following segment.

Program Development

The programs were developed on the basis of the following objective: "The learner can name in writing the set of cues for the instrument maneuver 'Vertical S-A' in correct order."

Objectives calling for learners to apply the cues to such stimuli as a pictorial or photographic representation of the instrument panel would have required different practice items for different levels of instructional cues. Since the inclusion of nonequivalent practice items might have represented an uncontrolled source of variance, the program objectives were restricted to naming behaviors only.

The programs were printed on 8.5" x 11" (21.5 cm x 27.9 cm) paper, and assembled in a spiral-bound booklet.

The programs underwent four revisions, and each version was tested on pilot subjects. As a result of these revisions, inconsistencies were eliminated, feedback was added after each learner response, and test times were noted.

Procedure

Students were normally scheduled one hour apart. An average time of 80 minutes was required for one student to complete the experiment. Usually two students were present: one in the simulator and one in the study carrel. One experimenter could easily direct the flow of subjects and monitor the data collection. Subjects were randomly assigned to one of the five groups.

For the cognitive pretraining, the experimenter placed the subject in the study carrel and instructed the subject to read the sheet of instructions entitled "For Your Information." The subject was told to mark the time he began work on the program and the time he finished the program. The cognitive posttest was taken immediately upon completion of the program. The subject marked the time when he finished the posttest. Perceptual-motor training took place immediately upon completion of the cognitive posttest. The subject was instructed to take a seat

in the simulator (left seat). The simulator was in "FREEZE" condition at 15000 feet, 160 knots, 360° and 61% RPM. After a standard USAF communication check, the subject was told to get comfortable, to adjust the rudder pedals and to use a light touch on the stick due to the stick's extreme sensitivity. The hood was then lowered and locked to reduce environmental interference, and the subject assumed control of the simulator after the experimenter had released the "FREEZE" switch.

The experimenter started the recorder, and the subject then flew straight and level for a period of five minutes. After five minutes, the subject started the first Vertical S-A maneuver. Upon finishing the maneuver, the subject flew straight and level for one minute and then started his second Vertical S. The subject continued to alternate Vertical S maneuvers with straight and level intertrial periods until six maneuvers were completed. The recorder was left on through the completion of the last maneuver. The experimenter kept a subject master sheet and a protocol sheet during this time. The subject master sheet served as the basic form for recording subject characteristics and elapsed times for the various phases of the experiment. The protocol sheet was used to record any deviation from experimental procedure, unusual noises, equipment malfunctions, and the experimenter's subjective impressions concerning student behavior.

After the sixth trial, the simulator was again put into the "FREEZE" condition. The subject left the simulator and answered a brief questionnaire designed to obtain some indication of the retention of instructional cues by the subject as well as to elicit some comment and critique of the pretraining procedures and materials. Upon completion of the questionnaire, the subject was dismissed.

Data Collection and Analysis

Cognitive posttests were scored independently for the percentage of correctly written cues by two judges using an algorithm in conjunction with a key. This procedure ensured a highly objective measure, free of any scorer bias.

The raw data for the computation of the perceptual motor performance descriptors were direct measures of six flight variables: airspeed, heading, altitude, vertical velocity, pitch attitude, and power. These measures were obtained automatically at one second intervals by tapping the analog input to the appropriate instruments. The recorder converted the analog voltages to digital signals and recorded these on precision cassette tape.

The precision with which the values of each variable could be identified and recorded was a function of the range of values which needed to be observed and the fixed recording capacity of eight bits per channel (i.e., variable) and observation. Airspeed, for example, had to be observed at the prescribed value of 160 knots plus and minus a margin wide enough to include even gross student errors. This margin was estimated on the basis of prior experimentation and set at +64 and -24 knots, resulting in a range of 88 knots which had to be observed.

Lost Data

Sporadic malfunctions of the mechanical components of the data collection device as well as occasional excessive noise in the analog signal of the simulator computer resulted in a certain amount of invalid data. These data were identified on the basis of a marker code and deleted from the experimental record with the aid of a computer program. The resulting experimental record, therefore, showed valid data interspersed with gaps varying in size from 1 to maximally 23 observations in length. The total loss of data for the experimental record was 3.75%.

The lost data were judged to be recoverable because all dependent measures were continuous, and the loss intervals were very short. The linear interpolation method was found to be most appropriate (Ludemann, 1974).

The procedure was successful for all measured variables except altitude. The recorded data for altitude had a high proportion of discontinuities or jumps which exceeded the performance limits of the simulator system, and were, therefore, not included in the data analysis.

Performance Descriptors

Measures of performance quality were obtained by comparing actual performance with the ideal or prescribed performance. Ideal performance for the Vertical S maneuver can be described in terms of mathematical functions. It is common practice to use certain criterion limits above and below the ideal values. The quality of a performance can then be described by indicating to what degree the actual performance was within a tolerance band described by the criterion limits.

The criterion limits used for the derivation of performance descriptors in the present experiment were based both on experiences gathered with various criterion limits during prior experimentation and on Fitts (1954), who used the standard deviation of the raw scores as criterion limits. A criterion which is more sensitive to differences between groups was obtained by dividing the standard deviation (over all subjects and trials) for a given variable by the square root of the number of groups. This manipulation yields a criterion which represents the standard error between group means and thus gives maximum discrimination between groups.

On the basis of the criterion limits, three different types of performance descriptors were computed using programming software developed for earlier data (Shipley, Gerlach, and Brecke, 1974). These performance descriptors, while interrelated, each summarize different aspects of pilot performance. Percent Time on Criterion (after Fitts, 1954) is a measure which combines a root mean square measure of performance error with the distribution of this error over time. Hit Rate is a straightforward ratio between number of observations which were within criterion limits and total number of observations. Error Amplitude represents the average size of the error exceeding the criterion limits

expressed in units of the criterion limit. In order to obtain one single performance score, the values for each descriptor were also combined as a straight linear sum over all five variables.

III. Results

It was hypothesized that transfer from cognitive processing to perceptual-motor performance on a standard instrument flight task would be a function of the type of instructional cues, the amount of practice incorporated in cognitive processing, and the flight training history of the subjects. The experimental groups were found to be equivalent in terms of age, hours on the T-37 airplane, and hours on the T-4 simulator. The groups were not equivalent with respect to the number of hours of flying time logged prior to entering flight training. The groups which received systematic cues had significantly more prior flight experience, $F(1, 38) = 12.17$, $p < .01$.

Adjustments were considered using an analysis of covariance procedure. Several reasons, however, led to the rejection of covariance analysis in favor of normal analysis of variance procedures.

1. Pearson product moment correlation coefficients were computed between three subject characteristics including hours of prior flying time and the scores on three composite perceptual-motor performance descriptors both for the straight and level warm-up period and for the Vertical S pitch portion. None of the correlations reached $p < .1$, the preestablished criterion for covariance procedures.

2. The one significant correlation for error amplitude during the straight and level portion must be considered inconclusive since none of the other composite performance descriptors show correlations which come close to significance ($p < .10$). The correlations with the average total performance scores are lower yet, and in this portion of the simulator performance error amplitude does not correlate at all systematically with hours of prior flying time.

3. The perceptual-motor performance data showed heterogeneous group variances. Analysis of variance is relatively robust with respect to violations of the assumption of homogeneity of variance, whereas analysis of covariance procedures are far less robust against violations of this assumption (Glantz, 1969).

4. Hours of prior flying time is a very incomplete indicator of pilot experience since it takes into account neither the type of flight training (private, commercial, military, single or multi-engine) nor the recency of such training. The potential effects of 50 hours of helicopter training ten years before the experiment cannot be equated with 50 hours of military single engine light plane training one-half year before the experiment.

The reasons cited above were considered ample justification for the choice of normal analysis of variance procedures. In all analyses, the 2 x 2 design was analyzed first. Then, comparisons between the

independent control group and the four experimental groups were [illegible] control group was not over-memorized prior to the [illegible] Fowler-Kiess comparisons, using Newman's Test (Myers, 1966b, p. 111).

Cognitive Performance

Cognitive memory as measured by percent correct recognition on the [illegible] subjects showed a significant learning-trial rate of effect, F (5, 30) = 5.56, p < .05. Subjects who had received acupressure rate obtained higher scores on the immediate memory than [illegible] did not receive current rate. Practice effects were not significant; scores were the [illegible].

Measures of time through progress and time through practice showed significant effects for practice, but not for learning-trial rate. Subjects who had received a high amount o. practice spent [illegible] more time working through the program, F (1, 30) = 10.07, p < .005; however, they spent significantly less time in completing the practice, F (1, 30) = 10.07, p < .05. Interactions were not significant.

Progress efficiency, obtained as the quotient between [illegible] and the [illegible] and time through progress by practice, i. [illegible] a significant practice effect, F (1, 30) = 11.34, p < .05. [illegible] to the low practice conditions made more correct responses as to the average per minute of learning time than subjects in the high practice conditions. Group means for cognitive performance measures are given in Table 1.

Perceptual Motor Performance

Three different types of derived scores, called a [illegible] scripture, were computed from the raw data gathered on Digital [illegible] Performance. Data analysed in 17 single variable performance [illegible] core which could be viewed across variables into the three [illegible] performance descriptors (the 18 criterion, hit rate, and [illegible]).

Analysis of variance procedures were applied to all 17 single variable scores as well as to the three composite performance scores. Separate analyses were conducted for the strength and [illegible] portion and for the one terminal 3 scores. This amounts to 3 + 2 [illegible] 20 separate analyses of variance. Since analyses on separate variable scores permit evaluation of only one of five measured variables of skill performance at one time, primary consideration is given to 3 depicting the results in terms of composite performance descriptors.

Strength and [illegible] scores. A significant [illegible] effect [illegible] was found for error amplitude, $F_{4,}$ F (3 [illegible]), p < .05. No other comparisons between the experimental [illegible] were significant. Newman's tests comparing each of the experimental groups with the independent control group did not reveal any significant differences.

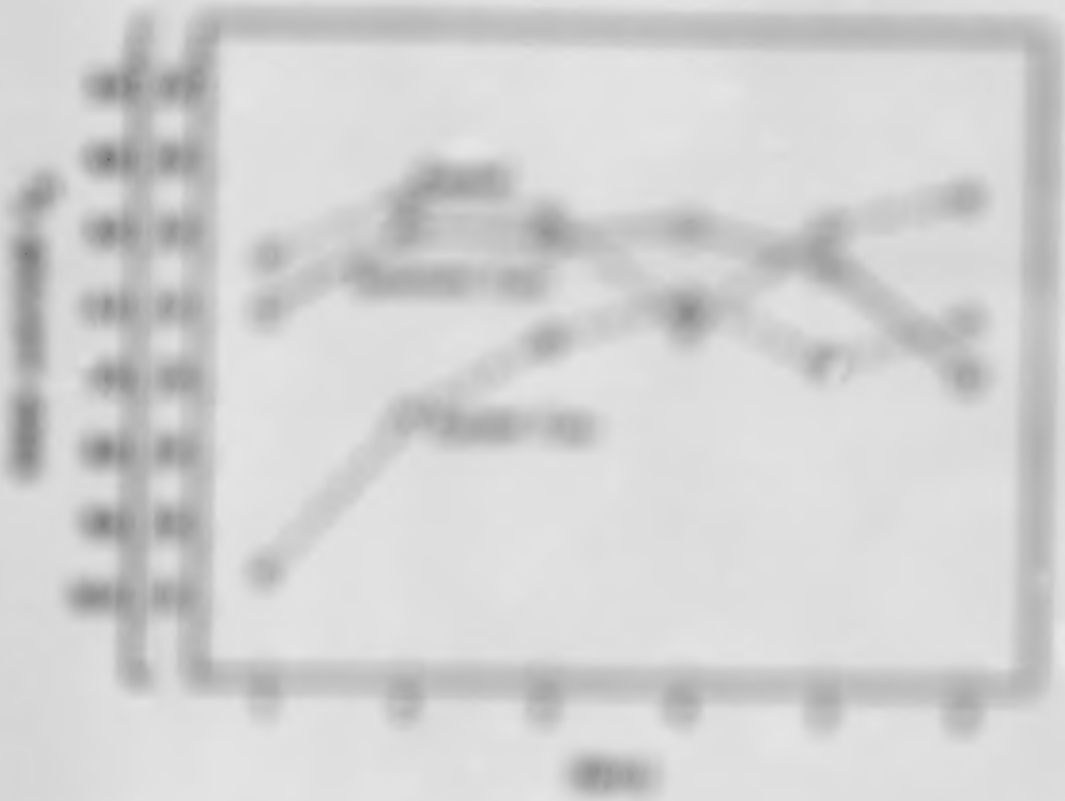
The group means on the three composite performance [illegible] are shown in Table 2.

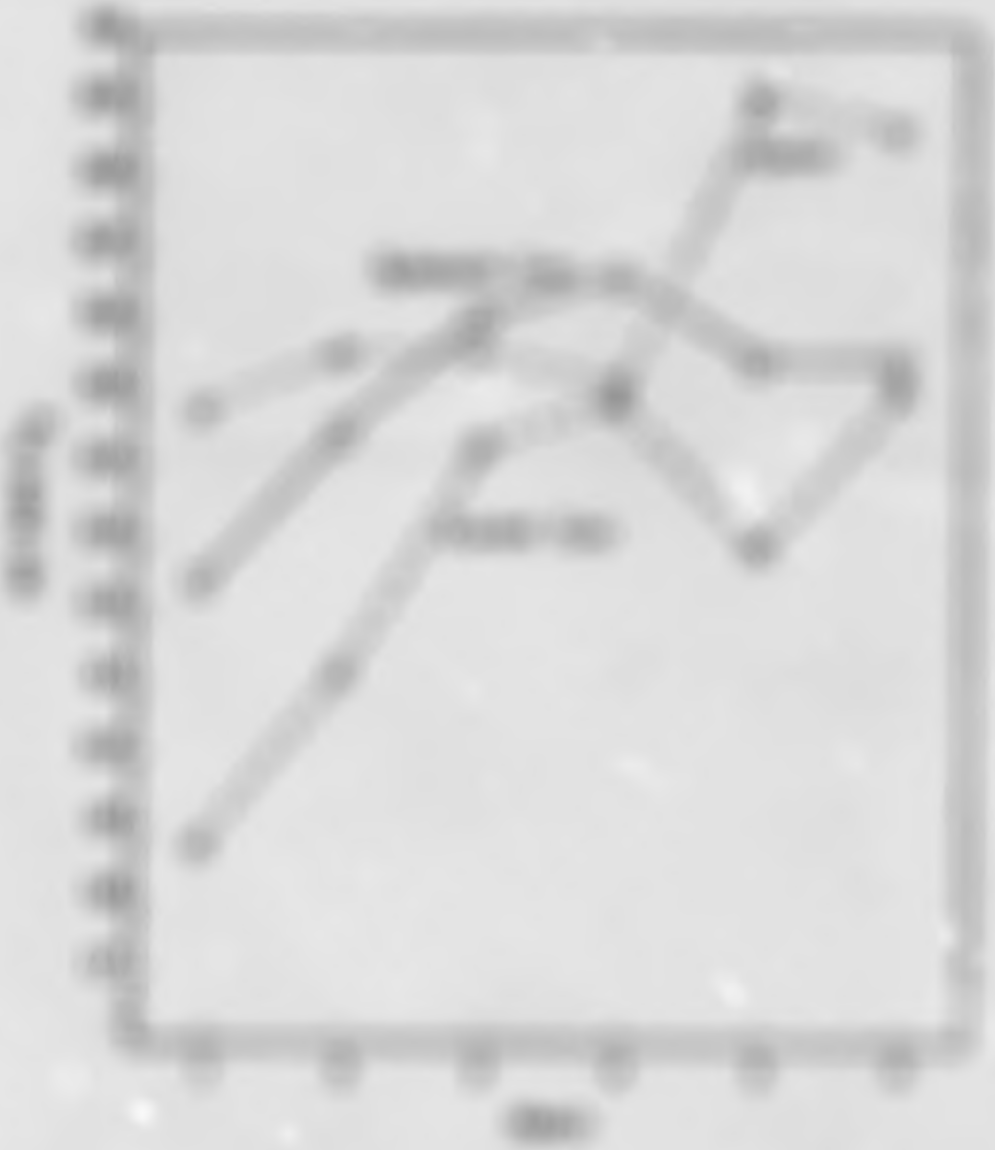
[illegible]

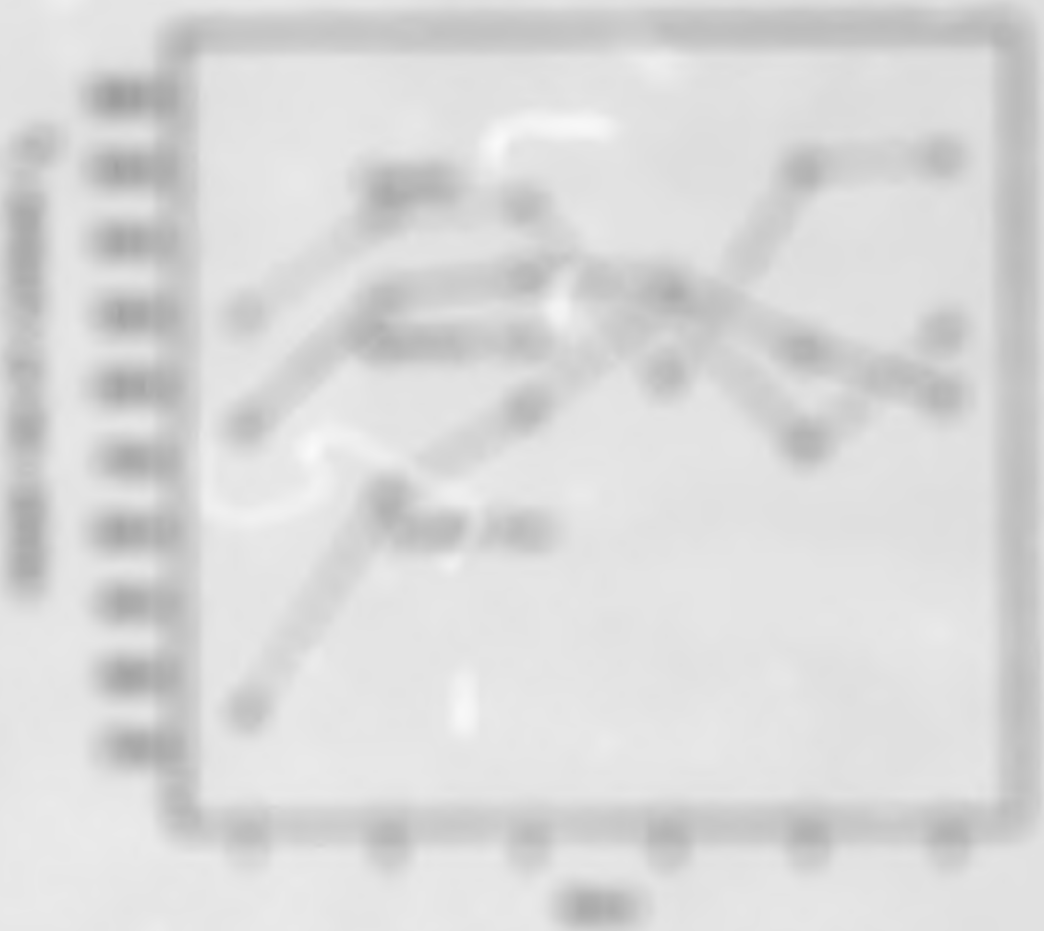
		[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]







IV. Discussion

The primary goal of this study was the identification of variables which influence transfer from cognitive pretraining to perceptual-motor skill acquisition. The results clearly support the central hypothesis that the direction of transfer is dependent on the type of VPRs or instructional cues which were learned during cognitive pretraining. Systematically developed rules led to more precise perceptual motor behavior than currently operational rules, which appeared to inhibit rather than facilitate performance. The results did not confirm the hypothesis that the amount of cognitive practice would be directly related to the amount of transfer.

The most significant specific finding of the cognitive phase was the superior posttest performance of groups which had received systematic cues. Subjects in this treatment condition achieved posttest scores which were on the average 17 percent above those receiving current cues. These higher scores were achieved at no expense in terms of time through program. It follows that systematic cues were much more readily retained.

The amount of cognitive practice with a given set of cues did not influence posttest scores, but it did lead to differences in posttest time. Subjects in the high practice conditions had significantly shorter posttest times than subjects in the low practice conditions. Since the posttest consisted of a straightforward reproduction of a list of cues, this result shows clearly that the cues were more readily recalled by subjects in the high practice condition. It is important to note, however, that greater readiness of recall does not entail greater precision of recall. Readiness of recall or cognitive availability of cues appeared to be a function of practice, whereas precision of recall varied with the type of instructional cue.

The two levels of instructional cues which led to differences in the precision of cognitive performance led to similar differences in the precision of perceptual-motor performance. The relatively high and stable initial performance of the systematic cues groups contrasts with the much lower and gradually increasing initial performance of the current cues groups. By Trial 4, all experimental groups had merged at a performance level which represents a performance ceiling for all but the control group.

These differential performance patterns indicate that systematic cues facilitate perceptual-motor performance in a way which permits the learner to perform at or near ceiling performance from the beginning. Current cues, by comparison, initially inhibit performance. This inhibiting effect gradually disappears as indicated by the gradual convergence of the essentially flat performance curve (see Figure 1) for systematic cues and the steadily ascending curve for current cues. In the absence of a true zero point of transfer effects, statements about transfer can only be made in relative terms. When contrasted with current cues, systematic cues show positive transfer effects. Relative to systematic cues, current cues show negative transfer effects.

The performance of the control group adds a reference point for these considerations on the effectiveness of VPRs. The control group subjects received the maneuver objective and were asked to write down the steps they would follow in executing the maneuver. This procedure essentially amounts to asking the subjects to analyze the maneuver and to supply their own cues. As Figure 1 shows, the control group performed at or above the performance level of the systematic cues groups. This result, which is in agreement with the superior performance for the "Analyzer" group in a study by Renshaw and Postle (1928), provides a positive boundary value of transfer with respect to the treatment conditions investigated so far. In relation to this boundary value, systematic cues can be considered maximally effective mediators of perceptual-motor skill, whereas current cues must be considered to be considerably less effective. The assumption that the direction of transfer is a function of the type of instructional cue is, therefore, supported at least in relative terms by the results of this study.

The two levels of cognitive practice which resulted in significantly different degress of cognitive availability of a given type of instructional cues did not lead to the predicted differences in perceptual-motor performance. Differences between systematic cues and current cues were expected to be smaller for low practice conditions than for high practice conditions. No significant performance differences due to practice effects were found.

It is speculated that the failure to find overall significant effects for the practice variable by regular analysis of variance procedures was at least to some extent a consequence of the instability of the T-4G simulator. In the questionnaire data, all but seven of the 39 subjects indicated that the simulator used in the experiment was "harder to fly" than either the aircraft or the regular training simulator. Increased information processing loads led to the common phenomenon of over-control, which in turn resulted in performance variances high enough to mask out any existing effects of the practice variable.

The high and heterogeneous variances associated with the perceptual motor data of the experimental groups also provide an explanation for the lack of significant correlations between cognitive mastery and perceptual-motor performance.

The second objective of the study was the discovery and validation of prescriptive principles for the design of perceptual-motor instruction. The predicted instructional effects of both previous research (Brecke et al., 1974) and the present study were confirmed by the experimental results which amount to an empirical validation of the design devices over two types of instructional treatments.

The results also provided empirical evidence for two previously uninvestigated considerations for the design of perceptual-motor instruction.

The high practice version of the instructional treatments was created by a straightforward repetition of identical mastery items. This manipulation led to a significant decrease of the instructional efficiency of the program and to negative attitudes on the part of the learners. The decrease of instructional efficiency was evidenced by the sharp increase of program time without concurrent increase in post-test scores. Evidence for the negative learner attitudes comes primarily from the significantly lower ratings for the instructional treatments which were given by the group which received current cues and high practice. It follows that instructional programs which are designed to provide cognitive pretraining should not incorporate repetitive practice of the type used in this study.

A second consideration for the design of perceptual-motor instruction stems from the performance exhibited by the control group. This group showed a very high performance for a very low investment in terms of cognitive pretraining time and an even lower investment in instructional development. The instructional treatment administered to the control group was definitely more efficient than all other instructional treatments administered. An instructional procedure which merely supplies the learner with an objective or with a precise idea of the desired goal performance and enlists the ingenuity of the learner in finding ways to attain this goal performance thus appears to be a more economical way to raise the instructional efficiency of pilot training than supplying the learner with explicit "how-to" rules which are very costly to develop. At the same time, such a procedure would be more effective than supplying the learner with instructional cues that are developed "on the spot" by instructor pilots who are not trained in instructional design.

If the learner is supplied with an explicit set of VPR's for each flight maneuver, he is essentially faced with the task of learning sets of procedures, i.e., lists of carefully sequenced sentences or sentence fragments. This may very easily lead to rote learning and mindless regurgitation. Even if rote learning can be avoided, this kind of instructional procedure is hardly conducive to the development of judgment, the ability to analyze flying tasks, and the ability to make autonomous decisions. It, therefore, appears that an instructional treatment which offers the possibility of attaining a high level of perceptual-motor performance on the one hand and a high level of generic cognitive skills on the other hand would be most advantageous.

References

Baker, K. E., and Wylie, R. C. Transfer of verbal training to a motor task. Journal of Experimental Psychology, 1950, 40, 632-638.

Brecke, F. H., and Gerlach, V. S. Model and procedures for an objective maneuver analysis (Technical Report No. 21201). Tempe, AZ: Arizona State University, Instructional Resources Laboratory, December, 1972.

Brecke, F. H., Gerlach, V. S., and Shipley, B. D. Effects of instructional cues on complex skill learning (Technical Report No. 40829, Project No. AFOSR 71-2128). Arlington, VA: U. S. Air Force Office of Scientific Research, 1974.

Eubanks, J. L. The role of verbal control in complex skill training (Technical Note No. 60115, Project No. AFOSR 75-2900). Bolling AFB, DC: U. S. Air Force Office of Scientific Research, 1976.

Fitts, P. M. The information capacity of the human motor system in controlling the amplitude of movement. Journal of Experimental Psychology, 1954, 47, 381-391.

Fitts, P. M., and Posner, M. I. Human performance. Belmont, CA: Wadsworth, 1967.

Frank, H. G. Kybernetische Grundlagen der Pädagogik (2nd ed.). Baden-Baden, West Germany: Agis Verlag, 1969.

Gerlach, V. S., Baker, R. L., Schutz, R. E., and Sullivan, H. J. Defining instructional specification. Englewood, CA: Southwest Regional Laboratory for Educational Research and Development, 1967.

Gerlach, V. S., Brecke, F. H., Reiser, R., & Shipley, B. D. The Generation of Cues Based on a Maneuver Analysis (Technical Report No. 21202). Tempe, AZ: Arizona State University, Instructional Resources Laboratory, December, 1972.

Goss, A. E., and Greenfeld, N. Transfer to a motor task as influenced by conditions and degree of prior discrimination training. Journal of Experimental Psychology, 1958, 55, 258-269.

Holton, R. B., and Goss, A. E. Transfer to a discriminative motor task as a function of amount and type of preliminary verbalization. Journal of General Psychology, 1956, 55, 117-126.

Ludemann, L. C. Approximation error for the estimation of a continuous unknown deterministic signal in noise from discrete time samples. In Proceedings of the 1974 IEEE Conference on Decision and Control. New York: The Institute of Electrical and Electronic Engineers, Inc., 1974.

Miller, G. A., Galanter, E., and Pribram, K. H. Motor skills and habits. In D. Legge (Ed.), Skills. Baltimore, MD: Penguin Books, Inc., 1970.

Myers, J. L. Fundamentals of experimental design. Boston: Allyn & Bacon, 1966.

Noble, C. E., Alcock, W. T., and Frye, R. L., Jr. The joint influence of practice and instructions on discrimination reaction time. Journal of Psychology, 1959, 48, 125-130.

Renshaw, S., and Postle, D. E. Pursuit learning under three types of instruction. Journal of General Psychology, 1939, 1, 365-367.

Richardson, A. Mental practice: A review and discussion. The Research Quarterly, 1967, 38, 95-107.

Shannon, C. E., and Weaver, W. The mathematical theory of communication. Urbana, IL: The University of Illinois Press, 1949.

Shipley, B. D., Gerlach, V. S., and Brecko, P. S. Measurement of flight performance in a flight simulator (Technical Report No. 40830, Project No. AFOSR 71-2128). Arlington, VA: U. S. Air Force Office of Scientific Research, 1974.

Weltner, K. Informationstheorie und Erziehungswissenschaft. Quickborn, West Germany: Verlag Schnelle, 1969.

Appendix

Post-Instruction Questionnaire

(The following questions are those to which reference is made in the text.)

8. Which part or aspect of the maneuver was the hardest?

_____

_____

9. What is the best pitch reference you can use during the maneuver?

_____

9. If you had your choice, which instructional procedure would you prefer to undergo to prepare for flying?
(Number in order of preference)

Selfstudy only
Selfstudy plus briefing by IP
Briefing by IP only
Programmed instruction
Programmed instruction plus briefing by IP

11. Which is harder to fly

the simulator used in the experiment
the regular simulator
the aircraft?
(check one)

14. Any other comments, remarks, suggestions?

_____

_____